ZJER

ZIMBABWE JOURNAL OF EDUCATIONAL RESEARCH

Volume 27 Number 1
March 2015

KNOWLEDGE • DELIGENCE • INTEGRITY

UNIVERSITY OF ZIMBABWE

Volume 27, Number 1, March 2015
ISSN 1013-3445

Contents **Page**

Experiential Approach to Teaching Statistics and Research Methods

Fred Zindi & Cribert Munetsi
Faculty of Education, University of Zimbabwe

Abstract

Statistics and research methods are among the more demanding topics for students of education to master at both the undergraduate and postgraduate levels. It is our conviction that teaching these topics should be combined with real practical experiences. We discuss an experiential teaching/ learning approach that guides 45 undergraduate students through two statistical and research methods projects. All 45 students are from the Faculty of Education of the University of Zimbabwe. We give the students minimal lectures and then let them carry on their own. We presuppose no mathematical training on the part of the students but explain simple school algebra concepts such as notation for summation, inequalities and equations of straight lines which might be unfamiliar to some. After that, the students are given a hands-on experience of statistics and research methods including take-home assignments. The students begin by conceptualising the application of statistics and research methods through lectures. They then move into the field to conduct their own research in small groups and later come to design their own examination on the topics. Thus they learn by doing. Students found this approach to be very worthwhile and useful, albeit a lot of work. Adaptation of experiential teaching/learning to other difficult areas is also discussed and recommended for future statistics and research methods classes.

Introduction

Although statistics and research methodology topics are among the most difficult to learn for college students undertaking courses in education, they have become increasingly important topics in the students' respective subject areas. The abstract or mathematical nature of these topics often presents a formidable obstacle for many students who find that the material does not readily engage their interest and that its applications and usefulness are not always immediately discernible. Unfortunately, traditional methods of teaching and learning, which involve lectures and readings, may not facilitate an optional understanding of these topics.

While the effectiveness of such traditional methods for conveying a great deal of information in a short period of time certainly is well established, the opportunity to "learn by doing" promotes a more synthesized integration of complex information (Mathie et al., 1993). Furthermore, pedagogy emphasizing an active and experiential approach to learning promotes greater interest and enjoyment (Weimer, 1987), and enhances critical thinking (Gorman et al., 1981; Halonen, 2000), and comprehension and retention (Birch, 2003). An ancient Chinese proverb provides a convincing argument for such experiential learning: "What I hear, I forget. What I see, I remember. What I do, I understand."

The lecture and reading methods, which a lot of instructors subject students to, are examples of difficult methodological approaches for which students often develop only the most rudimentary understanding of the subjects being taught. To promote student interest in this inherently unexciting material, instructors teaching statistics and research methods often have students select and do set exercises from text books as a way of 'understanding' the topics. However, while these activities provide valuable experience, they do not promote a thorough understanding of the theoretical foundations of the topics. In this article, we describe an experimental technique that directly exposes students to step by step statistical and research methods theories and practical aspects of these topics with assistance from student teaching assistants.

After introducing these topics in a classroom set-up, the students go out in the field in small groups, guided by a teaching assistant and collect data for later use in their research and statistics projects in the hope that by doing, they create better understanding of the topics. This method is time consuming and requires active supervision by the instructor and/or teaching assistant. Yet, using this approach, we have observed that students become quite enthused about learning this technical material and that they appear to comprehend thoroughly the meaning and purpose of statistics and research methods. Our method has been used in a 14-week (one Semester) course as well as in part- time classes.

Method

After a brief introduction on qualitative and quantitative methods for analysing data, each student decides on a topic one wants to research on then thinks about the statistical tools one might possibly use. The student then joins a group of three or four other students to form a research group. Students complete the first project (which is deciding on a topic they want to research on) individually and the second (which is going out in the field to collect data) in a small group. Instructors closely supervise all phases of the projects. As much as possible, the steps students follow in completing the projects are coordinated with lectures and readings on those topics. The students' are then asked to develop a pictorial description of data collected from the field (e.g. a supermarket). For instance, if an instructor wants to consolidate the students' understanding of chi-square statistical test in a research that involves the different brands of soap consumers buy leading to classification of data and frequency distributions, he instructs them to visit the supermarket and do their own observations in small groups (see examples 1 and 2 of the chi-square test in Table 1 below). Students working in small groups develop a graphical representation of the data they collect.

Test of knowledge

After several weeks in the course, students develop their own first course examination based on the statistics and research methods topics they have learned. This exercise goes towards their coursework grade. In order to discourage students from preparing only superficial or very easy items for the test blue print, the item writing exercise is closely monitored by the instructor. An explicit criterion in grading the exercise is the extent to which items require test-takers to think, understand and apply the material. The instructors then select a few items from this pool of several hundred and use them (with minimal editing) in the examination. The students then take the examination on a given date, knowing fully well that this is the same examination for which they developed items.

Examples of a practical research and statistics problem

Example 1

Students are sent out to a local supermarket to investigate the number of times consumers buy different brands of soap on display (adapted from Zindi & Munetsi, 2013).

In an investigation of the choices of soap made by customers in Pick n' Pay supermarket, e.g. Palmolive (A), Geisha (B), Lux (C), Sunlight (D) and Lifebuoy (E), we would expect each type of soap to be chosen equally often. Suppose there are five different brands of soap available and we want to observe 100 customers, each of whom will buy one type of soap, the expected number of choices (E) of each brand if there is no particular preference, will be 100÷5 =20.

But, suppose, according to our observation, we list the frequencies of choice of each brand, e.g., number of times each brand was chosen:

A	B	C	D	E
10	30	30	10	20

We use the formula $x^2 = \sum \frac{(O-E)^2}{E}$ and perform the following calculation.

Table 1

Chi-square (x^2) Test

Soap Brand	**Observed Frequency**	**Expected Frequency**	**O - E**	**(O - E)^2**	**$\frac{(O-E)^2}{E}$**
A	10	20	-10	100	5
B	30	20	10	100	5
C	30	20	10	100	5
D	10	20	-10	100	5
E	20	20	0	0	0
Total					**20**

Chi-squared =20

The df value is found by number of alternatives – 1. Therefore df = 4. Look up the chi-squared tables for obtained value of 20 and 4df. The results show that they do not fit the expected distribution and brands B and C are significantly preferred.

X^2 test under normal circumstances looks at the number of observations made in each category, and compares this with the number of observations which would be expected if there was no relationship between the variables and differences between the proportions in each category were simply a result of chance.

Example 2

In one school, 150 girls and 150 boys were interviewed for their preferences for employment. The results from the interview showed that 80 boys expressed a preference for teaching, 20 for work in the bank and 50 for nursing. The preferences of the 150 girls were: 9 for teaching, 80 for banking and 61 for nursing. Is there any significant difference in career choice between boys and girls?

Table 2

Contingency Table

	TEACHING	BANKING	NURSING	TOTAL
MALE	80^A	20^B	50^C	**150**
FEMALE	9^D	80^E	61^F	**150**
TOTAL	**89**	**100**	**111**	**300**

The expected frequency for each box is calculated using the formula

$$E = \frac{\text{Row total x column total}}{\text{Grand Total}}$$

Thus for 'box' A: $E = \frac{150 \times 89}{300} = 44.5$

for box B: $E = \frac{150 \times 100}{300} = 50$

for box C: $E = \frac{150 \times 111}{300} = 55.5$

for box D: $E = \frac{150 \times 89}{300} = 44.5$

for box E: $E = \frac{150 \times 100}{300} = 50$

for box F: $E = \frac{150 \times 111}{300} = 55.5$

Degrees of freedom = (number of rows - 1) x (number of columns-1) = (2-1) x (3-1) = 2

$X^2 = \sum \frac{(O-E)^2}{E}$ and perform the following calculation.

Table 3

Contingency Table

Box	Observed f	Expected F	O-E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
A	80	44.5	35.5	1260.25	28.32
B	20	50	-30.5	900.00	18.00
C	50	55.5	-5.5	30.25	0.55
D	9	44.5	-35.5	1260.25	28.32
E	80	50	30.0	900.0	18.00
F	61	55.5	5.5	30.25	0.55
TOTAL					**93.74**

Thus $X^2 = 93.74$ (i.e. the total of the final column)

Table of chi-square values shows that with 2 df and obtained value of 93.74, chi-square tabulated is 9.21at 1% level (or 5.99 at the 5% level).Our obtained value is way above that. There is therefore significance showing a marked difference in the choices of careers among boys and girls.

Yates Correction

If df = 1 an adjustment known as Yates Correction should be applied and X^2 is calculated using the formula:

$X^2 = \sum \frac{(O-E|-\frac{1}{2})^2}{E}$ and perform the following calculation;

(where |O-E| means that you only work out the difference between O and E ignoring whether O and E are positive or negative). This is mainly used for testing association, e.g., smokers vs bronchitis.

X^2 measures "goodness of fit" (how well the set of observed data conforms to some expected distribution).

Project summary

In order to assess the degree to which individual students learned from this group project, each student prepared a summary describing: the classroom lectures, the practical data collection methods in the field, the test construction process, the various decisions made during test development and the rationale for those decisions, the nature of the obtained data, aspects of statistics and research methodology that were not part of the project, and recommendations for refinement of the whole process. Students also rated the contribution of each member of their group, in order to identify non-participating students.

Results

At the end of the semester, students (N = 45) responded to a rating scale survey and several open-ended questions regarding their perceptions of and recommendations for the course and its projects. The areas of assessment included the experiential nature of the course, the workload, and the organization of content. Mean ratings and standard deviations pertaining to the rating scale items are presented in Table 1. The ratings could range from 0 to 4, but 66 per cent of the items have mean ratings above 3, indicating that students' perceptions were quite positive.

The lowest ratings were obtained on items concerning students' perceptions of the project difficulty and the amount of work required to complete them. This was no surprise. Even after considering that students typically regard course requirements to be excessive, we recognize that attempting to develop and pilot test an instrument in one academic term is a daunting task even for an experienced teacher. Nevertheless, students rated the value of the projects quite positively, saying that the workload and difficulty was justified by how much was learned. In fact, the average rating for items pertaining to the experiential nature of the course was above 3.5 on a 0-4 scale. Clearly, although students said that the approach is a lot of work, they found significant value in learning research methods and statistics experientially.

In response to an open-ended probe, 63 % of the students listed the hands-on projects as the greatest asset of the course. The other most frequently mentioned asset of the course was a greater understanding of basic statistics. Here, too, the lecture format was augmented by and integrated with experiential activities in which statistics were computed and interpreted on data with which students were very familiar. One student commented: "The great wall between statistics and students was broken down by the explanations of the function of statistics. The detailed explanation of how statistics work was the greatest asset of this course."

Table 4

Students Evaluation of the Research Methods and Statistics Course

QUESTION	M	SD
Experiential nature of the projects		
The opportunity to "learn by doing" was especially valuable in this course	3.53	0.55
Developing our own research and statistical analysis was a useful learning experience	3.61	0.54
The availability of the instructor or assistant for the computer part of the course was beneficial	3.56	0.59
Developing exam questions provide exposure to statistics that would not otherwise have been possible	3.51	0.63
Doing the item analysis on the exam questions helped me appreciate the difficulty of classroom testing	3.54	0.55
The final take-home assignment provide a good opportunity to demonstrate what I learned in this course	2.95	0.86
The final take-home project forced me to consolidate my understanding of the course topics	3.12	0.75
Workload		
The statistics assignment was too difficult for an undergraduate course in statistics and research methods	1.27	0.81
The statistics assignment was too much work for this course	1.32	0.98
The final take-home assignment was a lot of work, but was justified by how much I learned	2.70	0.90
Organization of content		
The lecture portion of this course corresponded nicely with the assignments given	3.19	0.60
Recommendations		
I would recommend the same format for this course in the future	3.37	0.77

Discussion

It would seem, then, that the wisdom of the Chinese proverb is supported: "...What I do, I understand." While our data and experiences are based on teaching statistics and research methods, the experiential methods can be easily adapted for classes in subjects other than statistics and research methodology. For example, students could collect data on themselves (e.g. physical measurements, demographic information. exam scores, questionnaires). Research design could be illustrated by using the data in predictive or experiential models, using control variables, etc. The data could then be analysed using statistical methods being taught in the class.

Having students prepare their own exam questions deserves special mention here because of its potential generalizability to classes in other content areas. While our purpose was to provide an experiential basis for understanding the basis of exams, this assignment provides an additional benefit. It is an impetus for students to think more carefully and critically about the material they are learning, as this is the only way to prepare high quality examination questions. Questions generated by students could still be graded and used for an actual course exam. Of course, to do so, students would need to be taught what constitutes a "high quality" question and how to construct one.

Conclusion

This topic is essential content in a tests and measurement course, but would be superfluous in many other courses. Are there disadvantages to teaching the statistics and research methodology course experientially? The approach creates a heavy work-load for the instructors and teaching assistants who must supervise and guide students' work. Consultation is often required at every step. Nonetheless, the value to the students seems clear: students understand and can use the technical processes of research methods and statistics In addition, like the students, we find that the effort is justified by the rewards – students were praised by other undergraduate instructors for their skills and those who proceeded to graduate school wrote back later saying that the course and the projects were among their most useful undergraduate experiences.

References

Birch, W. (2003). Toward a model for problem-based learning. *Studies in higher education, 11*, 73-82.

Gorman, M.E., Law, A., & Lindegren, T. (1981). Making students take a stand: Active learning in introductory psychology. *Teaching of psychology, 8*, 164-166.

Halonen, J.S. (Ed.). (2000). *Teaching critical thinking in psychology.* Milwaukee, Wl: Alverno Productions

Mathie, V.A., Beins, B., Benjamin, L.T., Jr., Wing, M.M., Hall, C.C.I., Henderson, B., McAdam, D.W., & Smith, R.A. (1993). Promoting active learning in psychology courses. In T. V. McGovern (Ed.), *Handbook for enhancing undergraduate education in psychology* (pp. 183-214). Washington, DC: American Psychological Association.

Weimer, M.G. (Ed.). (2002). *Teacher centred teaching*. San Francisco: Jossey-Bass.

Zindi, F., & Munetsi, C. (2013). Lecture notes on the chi-square test. Faculty of Education, University of Zimbabwe.